

more, Philadelphia, or New York. The caviar, which is usually prepared by the fisherman himself, is shipped to New York exclusively.

The rapid decline in the abundance of the sturgeon has caused the enactment of laws for its protection. The Virginia law states that no sturgeon less than 4 feet long may be removed from the waters of the State. The Maryland law states that no sturgeon weighing less than 20 pounds may be caught or offered for sale, and that no sturgeons whatsoever might be taken during the 10-year period from 1914 to 1923.

When a survey of the fishery industries of the United States was made in 1880 it was found that the Atlantic coast sturgeon industry was of relatively large importance. The industry centered at Delaware Bay and Savannah, Ga. Schooners sailed from Delaware during January and commenced operations early in February on St. Mary's River, Ga.

This sturgeon attains a large size, a maximum length of 18 feet having been recorded from Europe and, many years ago, from New England. At the present day the maximum for American fish is more nearly 12 feet, with fish 7 to 9 feet long not at all uncommon. The males average considerably smaller than the females, rarely exceeding a length of 7 feet.

Habitat.—On the Atlantic coast of America from the St. Lawrence River to the Gulf of Mexico. Also, once recorded from Hudson Bay, on the northwestern coast of Europe, if the American and European sturgeons are considered identical.

Chesapeake localities.—(a) Previous records: Chesapeake Bay and virtually all tributary streams. (b) Specimens in collection: None. The species, however, was observed at Lewisetta, lower York River, Buckroe Beach, Ocean View, and Lynnhaven Roads, Va., during 1921 and 1922.

28. *Acipenser brevirostrum* LeSueur. Short-nosed sturgeon.

Acipenser brevirostrum LeSueur, Trans., Amer. Philo. Soc., I, new series, 1817, p. 390; Delaware River. Uhler and Lugger 1876, ed. II, p. 155; Jordan and Evermann, 1896-1900, p. 106, Pl. XXI, fig. 47.

Acipenser brevirostris Smith and Bean, 1899, p. 181.

Head 5 to 6; depth about 8; D. 33; A. 19 to 22. Body much like that of *A. oxyrhynchus*; snout, as compared with *A. oxyrhynchus* of about the same size, shorter, more blunt, and proportionately wider at base; eye small, somewhat elongate; interorbital 2.2 to 2.8 in head, somewhat concave; mouth one-sixth wider than in specimens of *A. oxyrhynchus* of same size; two pairs of barbels placed in transverse line about midway between end of snout and anterior edge of mouth; never touching mouth when deflected; nostrils double, close together, in front of eye, the posterior pair the larger; skin rather smooth, compared with *A. oxyrhynchus*, but with small osseous points on unarmed portion; dorsal shields 9 to 12; lateral shields 23 to 29; ventral shields usually 7 or 8, but occasionally fewer; with or without preanal shields; fins situated as in *A. oxyrhynchus*.

Color blackish, tinged with olive, or reddish brown above; sides reddish mixed with violet, sometimes with oblique black bands; white underneath.

The above description was compiled from published accounts and the examination by us of a specimen taken off Provincetown, Mass., and now in the Museum of Comparative Zoology, Cambridge, Mass. This latter specimen had the following fin and shield counts: D. 33; A. 19; dorsal shields 10; lateral shields 26; ventral shields 7; preanal shields 2; length of fish about 30 inches.

This comparatively rare species resembles rather closely *A. oxyrhynchus*, and it had frequently been thought that it was a variable form of the latter. However, the descriptions given by LeSueur (1817) and by Ryder (1890) of short-nose sturgeons taken in the Delaware River leave little doubt as to the validity of the species. Ryder (1890, p. 238) states that "The characteristic dark brown or brown color of the animal, its small size, width of mouth, comparatively smooth skin, and early maturity render it impossible to question the identification which is thus established. The color alone is diagnostic; none of the young of the common species are dark colored, while the characteristic dirty olive green or brownish, with a shade of green in it, is always markedly characteristic of the common species at all stages of its growth."

Five specimens came under Ryder's observation, the smallest 18 inches and the largest not exceeding LeSueur's 33-inch specimen. The sexual organs of four of these (roes and milts) were far more developed than specimens of *A. oxyrhynchus* of corresponding sizes; in fact, the sexes of the latter species of these lengths could not be determined with certainty.

This fish was not seen during the present investigation and if it really occurs in the Chesapeake region (concerning which there seems to be some doubt notwithstanding that it has been recorded from there by at least two authors) it is not recognized by the fishermen.

The maximum length attained by this sturgeon is about 3 feet.

Habitat.—The only definite locality records belonging to this species, rather than the young of *A. oxyrhynchus*, are Provincetown, Mass. (described herein); New York, Bean (1903, p. 68); Delaware Bay, LeSueur (1817, p. 390) and Ryder (1890, p. 236); and Chesapeake Bay, Smith and Bean, (1899, p. 181).

Chesapeake localities.—(a) Previous record: Potomac River. (b) Specimens in the present collection: None.

Order HOLOSTEI

Family XVII.—LEPISOSTEIDÆ. The gar pikes

Body very elongate, more or less cylindrical; jaws produced, more or less beaklike, both armed with sharp teeth of various sizes; external bones of skull very hard and rugose; eyes small; nostrils near the end of upper jaw; gills 4, a slit behind the fourth; an accessory gill on the inner side of opercle; branchiostegals 3; air bladder cellular, lunglike, somewhat functional; spiral valve of the intestine rudimentary; scales consisting of rhombic plates, more or less imbricated and placed in oblique series running downward and backward; tail heterocercal, produced as a filament extending beyond the caudal fin in young; dorsal and anal fins placed far back and nearly opposite each other; ventral fins abdominal.

21. Genus LEPISOSTEUS Lacépède. Gar pikes

The characters of the genus are included in the family description. A single species is reported from Chesapeake waters.

29. *Lepisosteus osseus* (Linnaeus). Garfish; Gar pike.

Esox osseus Linnaeus, Syst. Nat., ed. X, 1758, p. 313; "Virginia."

Lepisosteus osseus Uhler and Lugger, 1876, ed. I, p. 182; ed. II, p. 154; Jordan and Evermann, 1896-1900, p. 109; Smith and Bean, 1899, p. 181.

Head 3.22; depth about 8.5; D. 8; A. 9; snout produced, 1.55 in head, its least width about 12.5 in its length; eye 13.1 in head; interorbitals 6; mouth very large; teeth numerous, both jaws with an outer series of small teeth, followed by a series of large, sharp canines projecting into pits in the opposite jaw when the mouth is closed, smaller rasplike teeth following the large teeth and occupying the jaws, vomer, and palatines; tongue well developed, emarginate or with a shallow slit in the free tip; external bones of the head hard, rough; scales bony, rhombic, platelike, with sharp posterior cutting edges; dorsal fin placed on posterior part of body, its origin over middle of base of anal; caudal fin rounded, unsymmetrical, the upper median rays longest, the lowest ray shortest; anal somewhat larger than the dorsal; ventral fins placed on the median part of the abdomen, a little nearer the base of the pectorals than origin of the anal; pectoral fins rather narrow, elongate, 3.35 in head. Color dark grayish above, silvery underneath; the vertical fins with large black spots; the paired fins plain olivaceous.

A single specimen (a partial skin 30 inches in length) forms the basis for the above description. The gar is generally common in the fresh waters of the central and eastern States and at times it ventures into salt water. It is not common in Chesapeake Bay, however. Fishermen operating at the mouth of the York River did not know the fish. Those operating pound nets in Lynnhaven Roads stated that the "garfish" was seldom caught in that vicinity.

The garfish is very variable, the local variations having given rise to about 28 specific names. It is readily recognized, however, by its produced, beaklike snout, rough, bony head and by the quadrate bony plates that cover the body. The posterior edges of these plates are somewhat free and very sharp. Large individuals are capable of cutting the fishermen's hands severely while bending the body from side to side in their struggle to escape.

This gar pike reaches a length of about 6 feet, and with its long beaklike mouth, provided with sharply pointed teeth, it is popularly believed to be a terror among other fish; but stomach examina-

tions made by various investigators have not fully borne out the reputation it has as a destroyer of other fish. It is essentially carnivorous, however, and no doubt feeds largely upon other fish. According to Smith (1907, p. 59), it spawns in the spring in shallow water. The species is nowhere valued as food, but in some localities, at least, the negroes smoke the meat to a limited extent for winter use.

Habitat.—From Vermont and the Great Lakes southward to the Rio Grande and west to Kansas and Nebraska.

Chesapeake localities.—(a) Previous records: Common in the brackish water of the Potomac and Patapsco (Uhler and Lugger, 1876); common in the Potomac River and tributaries (Smith and Bean, 1899); Havre de Grace, Md. (Bean, 1883); Elk River and Northeast River (Fowler, 1912); "vicinity of Norfolk, Va." (Moseley). (b) Specimens seen or captured during the present investigations: Bohemia River, Md., April, 1912, fyke net, length of specimen 33½ inches; lower York River, Va., July 8, 1921, pound net, salinity 1.0145, length of specimen 22 inches; Lynnhaven Roads, Va., May 19, 1921, pound net, salinity 1.015, length of specimen 30 inches.

Superorder TELEOSTEI. The bony fishes

Order ISOSPONDYLI

Family XVIII.—ELOPIDÆ. The ten-pounders

Body elongate, more or less compressed; mouth broad, the lower jaw projecting; maxillary extending beyond eye; premaxillaries protractile; an elongate bony plate between the branches of the lower jaw; villiform teeth on jaws, vomer, palatines, pterygoids, tongue, and base of skull; eye large, with an adipose eyelid; opercular bones with membranous border; gill membranes separate, free from the isthmus; branchiostegals numerous, 29 to 35; pseudobranchiæ present, large; lateral line present; scales small, wanting on head; dorsal fin inserted over or slightly behind ventrals, the last ray not produced, depressible in a scaly sheath; no adipose fin; caudal fin forked; axil of pectorals and ventrals each with a long accessory scale.

22. Genus ELOPS Linnaeus. Big-eyed herrings; Ten-pounders

Body elongate; opercular bones thin, with membranous borders; pseudobranchiæ present, large; lateral line straight, with simple tubes; scales thin, forming a very high sheath on dorsal and anal; axil of pectoral and ventral each with an excessively long accessory scale; dorsal fin anteriorly elevated, the last rays short; anal fin similar but somewhat smaller. The species of this genus are rather large fishes of wide distribution. The young are flat, ribbon-shaped, and they pass through a metamorphosis like the eels.

30. *Elops saurus* Linnaeus. Big-eyed herring; "Ladyfish"; "Jackmarriddle", Ten-pounder.

Elops saurus Linnaeus, Syst. Nat., ed. XII, 1766, p. 518; Carolina. Uhler and Lugger, 1876, ed. I, p. 154, ed. II, p. 131; Bean, 1891, p. 93; Jordan and Evermann, 1896-1900, p. 410, Pl. LXVII, fig. 178.

Head 4.15 to 4.35; depth 5.34 to 5.7; D. 22 to 24; A. 15 or 16; scales 114 to 116. Body quite elongate, compressed; the back not elevated; head low and long; snout moderate, a little depressed, its length 3.75 to 3.95 in head; eye in adult with well developed adipose lid, its diameter 5.2 to 5.75 in head; interorbital space 5; mouth large; terminal; maxillary reaching far beyond the eye in the adult, 1.3 to 1.8 in head; teeth all small, present on jaws, vomer, palatines, and tongue; gill rakers slender, 14 on the lower limb of first arch; scales rather small, with membranous borders, wanting on head, extending on base of caudal fin, and forming a broad sheath on base of dorsal and anal, an excessively large scale in the axils of the pectorals and ventrals; dorsal fin moderately elevated, its posterior margin deeply concave, its origin a little nearer base of caudal than tip of snout; caudal fin broadly and deeply forked; anal fin somewhat similar to the dorsal, but smaller, situated far behind end of dorsal, its origin a little nearer base of caudal than base of ventrals; ventrals rather small, inserted under origin of dorsal; pectorals rather small, similar to the ventrals, 1.8 to 2.2 in head. Color silvery, bluish on back, slightly yellowish below; dorsal and caudal dusky and yellowish; ventrals and pectorals yellowish with dusky punctulations.

A single specimen 565 millimeters ($22\frac{1}{4}$ inches) in length was taken during the present investigations. This fish and a smaller one from the St. Johns River, Fla., form the basis for the above description. The big-eyed herring, like the common fresh-water eel (and other eels), passes through a metamorphosis. The young, or larvæ, are similar to the leptocephalus of the eels, being greatly compressed, more or less ribbon-shaped, and transparent.

The big-eyed herring is readily recognized by the elongate form, low head, large mouth, and the broadly forked tail. This fish, like the tarpon, has a gular plate. The Atlantic and Pacific coast forms of this genus were long regarded as identical, but comparatively recent investigations have shown that the Atlantic representatives constantly have fewer gill rakers on the lower limb of the first arch. The range for the Atlantic species in this respect is 11 to 14, while that for the Pacific form is 18 to 20.

The food and feeding habits of this fish have not been studied thoroughly. It undoubtedly is carnivorous. Smith (1907, p. 116) says: "A specimen examined at Beaufort in August, 1901, had in its stomach six large shrimp (*Peneus*)."

The spawning habits of this fish, too, are imperfectly known, but it is probable that spawning takes place out at sea and that the eggs are pelagic. The larvæ, like the leptocephalus of the eel, are pelagic. These more oceanic allies of the herrings do not migrate to fresh water to spawn, as already stated, but individuals are not infrequently taken in brackish water.

The maximum size attained by the big-eyed herring is 3 feet (Jordan and Evermann, 1896-1900, p. 410), but the average size probably does not exceed 20 inches. This fish is evidently rather rare in Chesapeake Bay, since only a single specimen was taken during the present investigation

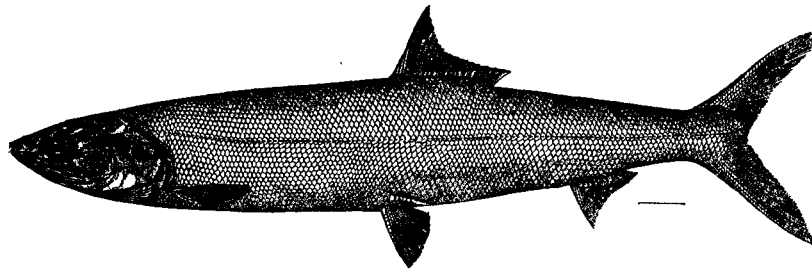


FIG. 40.—*Elops saurus*

and as fishermen report it as rare. "The species has no food value, the flesh being dry and bony." (Smith, 1907, p. 116.) Aside from the qualities of its flesh, it obviously is too rare in Chesapeake Bay to be of commercial importance in that vicinity.

Habitat.—The Atlantic coast, from Massachusetts to Brazil.

Chesapeake localities.—(a) Previous records: "Enters our large rivers from the salt waters of Chesapeake Bay, but seems to be quite common." (Uhler and Lugger, 1876); Cape Charles, Va. (Bean, 1891). (b) Specimen in collection: Lynnhaven Roads, September 17, 1921, taken in a pound net.

Family XIX.—MEGALOPIDÆ. The tarpons; The grande-ecailles

This family, as here understood, differs from the Elopidae in the large scales, absence of pseudo-branchiæ, and in the greatly produced (filamentous) last ray of the dorsal fin.

23. Genus TARPON Jordan and Evermann. The tarpon

Body oblong, rather strongly compressed; mouth large, very oblique, the lower jaw strongly projecting; maxillary broad, extending beyond eye; pseudobranchiæ wanting; lateral line decurved; scales very large, not forming a sheath on dorsal or anal; axil of pectoral and anal with a moderately large accessory scale; dorsal fin anteriorly elevated, the last rays of fin produced, filamentous; anal fin similar but larger, the last ray not notably produced; ventrals inserted well in advance of dorsal.

31. *Tarpon atlanticus* (Cuvier and Valenciennes). Tarpon; Silverfish; Jewfish.

Megalops atlanticus Cuvier and Valenciennes, Hist. Nat. Poiss., XIX, 1846, 398; Guadeloupe, San Domingo, Martinique, Porto Rico.

Megalops thrissoides Lugger, 1878, p. 121.

Tarpon atlanticus Jordan and Evermann, 1896-1900, p. 409; 1900, Pl. LXVII, fig. 177.

Head 4.1 to 4.3; depth 3.4 to 3.85; D. 12 to 15; A. 20 to 23; scales 42 to 47. Body elongate, rather strongly compressed; the ventral outline much more strongly curved than the dorsal; dorsal profile slightly concave over head; head moderate, notably compressed; snout short, broad, 4.8 to 5.1 in head; eye 3.9 to 4.65; mouth large, oblique, the jaws strongly curved; the lower jaw much in advance of the upper; maxillary reaching far beyond eye, 1.5 to 1.7 in head; teeth all small, in villiform bands; gill rakers slender, 32 to 36 on lower limb of first arch; lateral line decurved; scales very large, cycloid, wanting on head, present on base of anal but wanting on dorsal, the accessory scale in the axil of pectoral and ventrals less than half the length of fin; dorsal fin short, anteriorly notably elevated, the last ray filamentous, nearly equal to depth of body; caudal fin broadly forked, the lobes equal; anal fin deeply falcate, similar to the dorsal but longer, the posterior rays somewhat produced but not filamentous; ventral fins moderate, inserted well in advance of origin of dorsal; pectorals inserted low, under posterior margin of opercle, 1.1 to 1.16 in head. Color uniform bluish-silvery above; sides and lower parts bright silvery; pectoral and ventral fins pale, the other fins more or less dusky.

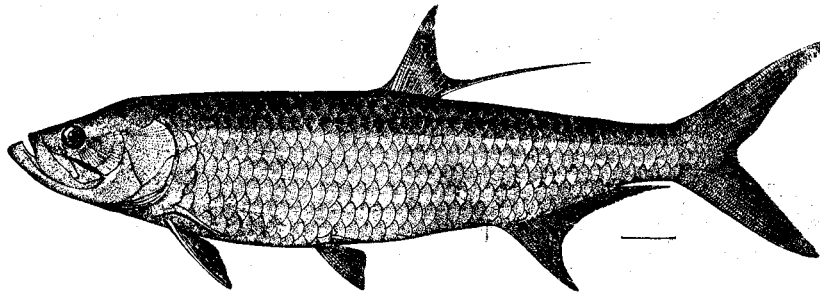


FIG. 41.—*Tarpon atlanticus*

The tarpon was not seen in Chesapeake Bay during the present investigation, but it was reliably reported by fishermen. The species is readily recognized by the large silvery scales, decurved lateral line, and the small dorsal fin, which is smaller than the anal and which has the last ray produced into a long filament.

The tarpon feeds largely on small fish and at times it ascends fresh-water streams, presumably in pursuit of its prey. It is a powerful and active swimmer and it has the habit of leaping entirely above water. The purpose of these leaps remains unexplained, but it is generally supposed that this is a form of play. The spawning habits of this species are little known. The eggs and young of the American tarpon have never been found and the spawning grounds are unknown. The young of the oriental tarpon pass through a stage of metamorphosis similar to Elops. The smallest specimens of tarpon of which a record has come to the notice of the present writers are reported by Evermann and Marsh (1902, p. 80). These specimens were collected at Fajardo, Porto Rico, and they ranged in length from $2\frac{1}{4}$ to $3\frac{1}{4}$ inches. All the specimens reported from our coast were comparatively large individuals. The tarpon reaches a maximum length of about 8 feet. It is a game fish of considerable importance and is much sought by anglers. Its flesh, however, is coarse and of little value. The large, silvery scales are frequently sold as curiosities or as souvenirs, and at times they are used in ornamental work and in the manufacture of artificial flowers.

The species is too rare in Chesapeake Bay to be of economic importance, as it is taken only occasionally.

Habitat.—Massachusetts to Brazil; rarely as far north as Nova Scotia.

Chesapeake localities.—(a) Previous records: "Vicinity of Norfolk, Va." (Moseley, 1877, p. 9); Crisfield (Lugger, 1878, p. 121). (b) Specimens in the present collection: None. However, the species was reliably reported by fishermen operating in the southern parts of Chesapeake Bay.

Family XX.—CLUPEIDÆ. The herrings

Body oblong or elongate, more or less compressed; belly rounded or compressed, usually armed with bony serratures when compressed; mouth rather large, terminal, or more or less superior, with the lower jaw projecting; premaxillaries not protractile; teeth usually small, often feeble or wanting, variously arranged; adipose eyelid present or absent; gill rakers long and slender; gills 4, a slit behind the fourth; branchiostegals 6 to 15; pseudobranchiæ present; lateral line wanting; scales cycloid or pectinate; dorsal fin usually about median, rarely wanting; no adipose fin; ventral fins, if present, moderate or small; anal fin usually rather long; caudal forked, vertebræ 40 to 56.

KEY TO THE GENERA

- a. Scales with their posterior edges round and smooth, or nearly so, never pectinate; cheeks and opercles not exceedingly broad; intestine of moderate length.
- b. Last ray of dorsal normal, not produced into a long filament; vertebræ 46 to 56.
- c. Vomer with a patch of permanent teeth; abdomen not strongly compressed; ventral scutes rather weak.....Clupea, p. 81
- cc. Vomer without teeth; abdomen rather strongly compressed; ventral scutes prominent.
- e. Cheeks as long as or longer than deep; jaws with minute teeth.....Pomolobus, p. 82
- ee. Cheeks deeper than long; jaws in the adult without teeth.....Alosa, p. 93
- bb. Last ray of dorsal produced into a long filament; vertebræ about 40 to 44...Opisthonema, p. 101
- aa. Scales with the posterior edges nearly vertical and strongly pectinate; cheeks and opercles very deep; intestine very long.....Brevoortia, p. 102

24. Genus CLUPEA Linnæus. Herrings

Body long, compressed, with median line of abdomen armed with hard, bony scutes; maxillary with a broad supplemental bone; vomer with a permanent patch of teeth; vertebræ 46 to 56. A single species is known from the Atlantic coast, and it occurs in Chesapeake Bay only as a rare straggler.

32. *Clupea harengus* Linnæus. Sea herring.

Clupea harengus Linnæus, Syst. Nat., ed. X, 1758, p. 317; European seas. Lagger, 1877, p. 87; Jordan and Evermann, 1896-1900, p. 421, Pl. LXX, fig. 185.

"Head 4.5; depth 4.5; eye 4; D. 18; A. 17; lateral line 57; ventral scutes 28+13; vertebræ 56. Body elongate, compressed. Scales loose. Cheeks longer than high, the junction of the mandible and preopercle under middle of eye. Maxillary extending to middle of eye; upper jaw not emarginate, lower jaw much projecting. Vomer with an ovate patch of small permanent teeth; palatine teeth minute, if present; tongue with small teeth; jaws with or without minute teeth. Gill rakers very long, fine, and slender, about 40 on the lower part of the arch. Eye longer than snout. Dorsal inserted rather behind middle of body, in front of ventrals. Pectorals and ventrals short, anal low. Abdomen serrated in front of ventrals as well as behind, the serratures weak. Bluish; silvery below, with bright reflections. Peritoneum dusky." (Jordan and Evermann, 1896-1900.)

This species was not seen during the present investigation, and apparently it is not recorded from Chesapeake Bay in a published work. The species is included here on the authority of certain field notes by Dr. W. C. Kendall, which he has kindly placed at our disposal and which were made during an investigation in Chesapeake Bay in 1894. Doctor Kendall reports having taken one specimen, 12 inches long, on March 13 in a pound net near Hampton, Va., and he also states that according to the fishermen this herring is caught occasionally.

The sea herring may be recognized by the rather slender body, thin, deciduous scales, weak scutes on the ventral edge, and by the presence of a patch of teeth on the roof of the mouth.

The food of the sea herring consists of small organisms, chiefly copepods, and the larvæ of worms, mollusks, and other planktonic forms. It is stated in Bigelow and Welsh (1925, p. 103) that "the larvæ (European) feed on larval gastropods, diatoms, peridinians, and crustacean larvæ, but they soon begin taking copepods, and after they are 12 millimeters long depend on them exclusively for a time. * * * As they grow older they feed more and more on larger prey, turn-

ing to the larger copepods and amphipods, pelagic shrimps, and decapod crustacean larvæ." Moore (1898, p. 402) examined a large number of adult herring taken near Eastport and found them feeding solely on copepods and pelagic shrimps, while the young less than 4 inches long fed only on the former.

Along the western North Atlantic coast the herring spawns during the spring, summer, and fall, the spring and the fall being the chief seasons. The fish spawns all along the coast from Nova Scotia to Block Island within 25 miles of land and at depths usually not exceeding 75 fathoms. The eggs are adhesive and demersal and they adhere to seaweeds and other objects on the bottom. They are 1 to 1.4 millimeters in diameter, and an individual fish, according to size, deposits from 20,000 to 40,000. The period of incubation ranges from 11 days at 50° F. to 40 days at 38.3° F. According to Bigelow and Welsh (1925, p. 94), 10 to 15 days might be stated as an average for the Gulf of Maine. The larvæ are about 5 to 6 millimeters long at the time of hatching, and when a length of 40 millimeters is attained adult characters are nearly developed.

The sea herring is perhaps the most important food fish in the world. Occurring in countless numbers on both sides of the Atlantic, it is preyed upon by many species of fish, as well as whales. One of the chief enemies of young herring is the squid. This fact is known by many investigators, but we had occasion to watch the wholesale destruction of 2 to 4 inch herring during June, 1925, on the flats about Provincetown, Mass. Schools of 10 to perhaps 50 squids circled around a school of herring until they had bunched their prey into a compact mass. Individual squids then darted in and seized one, sometimes two, herring, ate only a small portion, and then darted back for more. Along the beach there remained a silvery streak of dead herring.

During 1919 the catch of herring in the Gulf of Maine amounted to about 110,000,000 pounds (Bigelow and Welsh, 1925, p. 105), of which about 80 per cent were sardines (young of about 3 to 5 inches) while the remainder were adults utilized as food and bait for cod and other banks fish.

The sea herring is principally a North Atlantic species and is very abundant on both coasts of the Atlantic Ocean. It is said to be the most important as well as the most abundant food fish in the world. This herring is not only an important article of food for man but it is of great importance as food for the larger fish of the North Atlantic, such as the cod, haddock, halibut, bluefish, and many others. The herring is used in the fresh, salted, smoked, and canned state, and it is also used as bait in the line fisheries for cod, haddock, etc. The maximum length attained by the species is given as 18 inches.

Habitat.—North Atlantic Ocean, on the coasts of Europe and America. Recorded as far south on the American coast as Cape Hatteras, and northward to northern Labrador.

Chesapeake localities.—(a) Previous records: None. (b) Specimens in present collection: None. The present record is based upon a field note by Dr. W. C. Kendall, made on March 14, 1894, in which he reports having taken a specimen 12 inches long from a pound net near Hampton, Va.

25. Genus *POMOLOBUS* Rafinesque. Alewives; River herrings

Body oblong, compressed; belly strongly compressed, serrate; mouth moderate, terminal, or the lower jaw projecting; teeth weak, no patch on vomer; cheeks usually longer than deep; an adipose eyelid present; dorsal fin short, nearly median; scales cycloid or with an emarginate membranous border, deciduous. Three of the four American species are found in the Chesapeake waters.

KEY TO THE SPECIES

- a. Gill rakers rather few, 19 to 21 on the lower limb of the first arch; mandible strongly projecting entering into the general dorsal outline of the head, no pronounced angle on the upper margin near the median point of its length; tip of snout and lower jaw conspicuously dusky; peritoneum pale *mediocris*, p. 83
- aa. Gill rakers numerous, about 25 in very young, 40 to 50 in adults; mandible not strongly projecting, never entering into the general dorsal outline of the head, a very prominent angle on the upper margin near the median point of its length, posteriorly very deep; the tip of snout and lower jaw not conspicuously dusky.

- b. Eye of moderate size, the diameter about equal to length of snout; color of back bluish green; peritoneum black.....*æstivalis*, p. 85
 bb. Eye large, its diameter greater than length of snout at all ages; color of back grayish green; peritoneum pale.....*pseudoharengus*, p. 89
33. *Pomolobus mediocris* (Mitchill). Hickory shad; Hick; Hickory jack; Bone jack; Fresh-water tailor.

Clupea mediocris Mitchill, Trans., Lit. and Philo. Soc., N. Y., I, 1814, p. 450; New York.

Pomolobus mediocris Uhler and Lugger, 1876, ed. I, p. 159; ed. II, p. 136; Goode, in McDonald, 1879, p. 14.

Clupea mediocris Bean, 1883, p. 366.

Pomolobus mediocris Jordan and Evermann, 1896-1900, p. 425, Pl. LXXI, fig. 188; Smith and Bean, 1899, p. 183; Fowler, 1912, p. 51.

Head 3.5 to 3.9; depth 3.1 to 3.7; D. 15 to 18; A. 20 or 21; scales 45 to 50. Body rather slender, compressed, dorsal profile straight over the head, gently convex from nape to dorsal fin; ventral outline more strongly rounded than the dorsal, without a prominent angle at the base of mandible; the margin of the abdomen compressed and provided with bony scutes; head long, not very deep; snout moderate, 3.75 to 4.2 in head; eye 4.2 to 5; interorbital 5.46 to 7; mouth rather large, superior; maxillary broad, reaching a little beyond middle of eye, 2.05 to 2.42 in head; cheek about as deep as long; mandible projecting very prominently, the tip not included in the upper jaw and entering

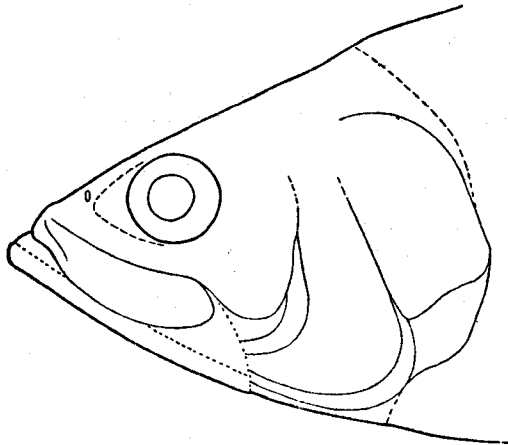


FIG. 42.—*Pomolobus mediocris*. Note strongly projecting mandible which enters into dorsal profile

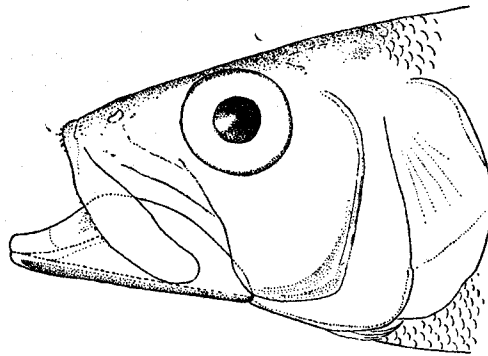


FIG. 43.—*Pomolobus mediocris*. Note that outline of upper margin of mandible bears no pronounced angle

into the dorsal profile, its upper margin without a prominent angle near the middle of its length (similar in outline to that of *Alosa sapidissima*); teeth very small, present on jaws, palatines, and tongue; gill rakers rather long and slender, 19 to 21 on the lower limb of the first arch; scales of moderate size, with emarginate membranous border, more or less deciduous; ventral scutes 20 or 21 in advance of ventrals and 14 to 16 behind ventrals; dorsal fin small, the outer margin straight or slightly concave, its origin equidistant from tip of snout and vertical from base of last anal ray; caudal fin forked, the lobes symmetrical and of equal length; anal fin longer than the dorsal but much lower, its origin a little nearer the base of ventrals than base of caudal; ventral fins rather small, inserted about equidistant from base of pectorals and origin of anal; pectoral fins of moderate size, similar to the ventrals but larger, 1.25 to 1.7 in head.

Color grayish green above, silvery on sides and below, more or less iridescent. A dark shoulder spot, followed by several obscure dark spots; faint dark spots at base of scales on upper part of sides, forming longitudinal dark lines. Nape green, opercle brassy, tip of snout dusky. Dorsal and caudal dusky; anal and ventrals plain translucent; pectorals slightly dusky. The dark lateral stripes are most conspicuous on specimens that have lost their scales, the black being on the skin underneath the scales and showing faintly through the somewhat transparent scales. The dark lines along the rows of scales are not evident in the small specimens (155 to 190 millimeters) examined. Peritoneum pale.

Fourteen specimens of this species, ranging from 155 to 328 millimeters ($6\frac{1}{8}$ to 13 inches) in length, form the basis for the above description. This species is recognized by the strongly projecting lower jaw, which distinctly enters into the dorsal profile, and by the small number of gill rakers on the lower limb of the first arch. It agrees with *Alosa sapidissima* in the general shape of the mandible, and it differs from the other species of *Pomolobus* in the absence of a prominent angle near the median point of its length.

Doctor Linton examined seven stomachs from specimens taken on five different dates and at three localities in Chesapeake Bay. Four stomachs were virtually empty, but the small fragments found in washings indicated a fish diet. The other three stomachs contained the remains of fish exclusively. Two stomachs examined by us, taken from fish caught in April, were entirely empty. Bean (1903, p. 198) states that specimens taken near New York City and examined by him had fed on sand launces, each stomach containing from 15 to 20 of these animals, ranging from $3\frac{1}{2}$ to 5 inches in length. Many stomachs of fish caught at Woods Hole, Mass., and examined by Vinal N. Edwards, contained, besides various species of small fish, squids, fish eggs, small crabs, and various pelagic crustaceans.

The habits of the hickory shad are even less perfectly understood than are those of the branch herring and the glut herring. Jordan and Evermann (1896-1900, p. 425) and Fowler (1906, p. 95), state that this fish does not ascend fresh-water streams to spawn. McDonald (1884, p. 609) says that no observations have been made on the breeding habits but that it is almost certain that the species spawns in the spring, and he thinks that it is "more than probable" that it spawns in fresh water under the same conditions as the shad but at a little earlier period. Smith (1907, p. 121) says: "The species is common in the coast waters and rivers of North Carolina, coming in from the ocean in the late winter or early spring and ascending streams to spawn, going to the headwaters in company with the branch herring." Not a single fish less than 155 millimeters ($6\frac{1}{8}$ inches) in length occurs in the present Chesapeake collection, and young previously reported from Chesapeake waters (so far as we have been able to secure the specimens for examination) were wrongly identified. Extensive collections of Clupeidae were made in the Potomac River, in the fresh waters in the vicinity of Havre de Grace and at many points in the bay. The collections in the Potomac were made chiefly during the summer and fall, those at Havre de Grace in the spring, late summer, and fall, and those in the bay were made at all seasons of the year in both shallow and deep water. The fact that not a single young hickory shad (of less than 155 millimeters in length) was taken throughout these investigations shows rather conclusively that the hickory shad does not ascend the fresh waters of the Chesapeake region to spawn. Five adults examined, taken during April and May (four females and one male), all had the roe somewhat developed but not ripe. The information gathered during the investigation leads to the belief that the hickory shad leaves Chesapeake Bay to spawn.

A definite spring run and a somewhat less definite fall run of hickory shad takes place in Chesapeake Bay. During the summer only stragglers are taken. Hickory shad are taken with the opening of pound-net fishing in the lower bay early in March. Like the shad and the alewives, the first fish appear sometime later in the upper reaches of the bay. In the lower Potomac the bulk of the catch is taken late in March and early in April, agreeing in this respect with the Lynnhaven Roads region; but in the vicinity of Havre de Grace the run does not occur until late in April and early in May. Most of these fish range in length from 14 to 18 inches.

This fish is taken during summer in all parts of the bay, at least as far north as Baltimore. The individuals are smaller fish than those of the spring and fall runs, measuring from 8 to 12 inches in length. The number of fish taken in a set of pound nets during the summer (if, indeed, any at all are caught) usually ranges from one to six per day.

In the fall a definite but somewhat smaller run than that in the spring occurs. The fall fish are taken mostly in the lower parts of the bay, from Solomons, Md., southward. In a set of two pound nets in Lynnhaven Roads, fishing from November 1 to 16, 1921, from none at all to 100 pounds a day were caught; while in two nets fishing from November 16 to December 5 at Ocean View daily catches of 100 to 400 pounds were taken, the catch for the last day being 150 pounds. Virtually all fishing ceases by December 1, consequently we do not know at what date this fall run of fish ends, but in view of the catch made on December 5 it appears probable that a few fish, at least, remain after the nets are lifted. The fall fish are of about the same size as those of the spring

run. In the lower bay the hickory shad is often the principal species caught at the very end of the fishing season.

The maximum length attained by the hickory shad, according to published accounts, is about 2 feet. Uhler and Lugger (1876, p. 159) state that it attains a length almost equal to that of the shad. Observations made during the present investigations indicate that the maximum length now attained by this fish in Chesapeake Bay is about 18 inches, with a weight of 2 pounds. The average length of market fish, however, is only about 15 inches and the weight 1 pound.

The hickory shad has some commercial value, especially in the southern parts of the bay, where it is one of the first in the spring and one of the last fish in the fall to be caught in considerable quantities. During 1920 it ranked fourteenth among the fishes of Chesapeake Bay in quantity and fifteenth in value, the catch amounting to 218,620 pounds, worth \$8,245. The bulk of the catch is taken in pound nets in March, after which a decline occurs and only stragglers are caught after April 15 in all sections of the bay except in the extreme northern stretches, where the spring run occurs later, as shown elsewhere. A smaller catch of fish is made in the late fall, and sometimes at the very end of the fishing season the hickory shad is the principal species caught. The following catches made by a set of two pound nets in Lynnhaven Roads, Va., in 1914 is somewhat typical of the hickory-shad catch made in the southern parts of the bay: March 10 to 31, 25 to 600 pounds per day; April 1 to 15, 10 to 100 pounds per day; April 16 to 30, less than 10 pounds per day; November 1 to 16 (end of season); none to 100 pounds per day.

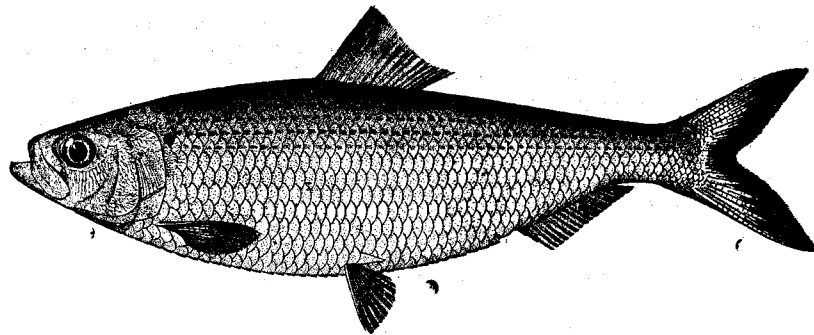


FIG. 44.—*Pomolobus æstivalis*. Male, 10.6 inches long

The fishermen separate the hickory shad from the alewives and shad, as the prices of each of these species differ widely. In April, 1922, run-boat buyers were paying 5 cents each for hickory shad, regardless of size. When the fish are packed in boxes and shipped direct to market they are sold by weight. The retail price in 1922 ranged from 10 to 15 cents per pound.

Habitat.—Maine to Florida, entering streams, except in New England.

Chesapeake localities.—(a) From virtually all streams tributary to Chesapeake Bay and from many localities within the bay. (b) The immature specimens in the collection, ranging from 155 to 255 millimeters ($6\frac{1}{8}$ to 10 inches) in length, are from Annapolis, Md., to Smith Point, Va., taken with the beam trawl at depths ranging from 16 to 27 fathoms from January 19 to March 18, 1914; Lynnhaven Roads, Va., June 9; Buckroe Beach, Va., June 22, 1921, taken in pound nets.

34. *Pomolobus æstivalis* (Mitchill). Herring; Glut herring; Blue herring; Greenback herring; Alewife.

Clupea æstivalis Mitchill, Trans., Lit. and Phil. Soc., N. Y., I, 1814, 456; New York. Bean, 1883, p. 366.

Pomolobus pseudoharengus Uhler and Lugger, 1876, ed. I, p. 158; ed. II, p. 135 (in part).

Pomolobus æstivalis Goode, in McDonald, 1879, p. 14; Jordan and Evermann, 1896-1900, p. 426, Pl. LXXI, fig. 190; Smith and Bean, 1899, p. 183; Evermann and Hildebrand, 1910, p. 158.

Head 3.33 to 4.5; depth 3.35 to 4.25 (average for 22 specimens, 3.6); D. 16 to 19; A. 18 to 21; scales 47 to 52. Body moderately elongate, compressed, slightly deeper in the adult than in the young; dorsal profile from snout to dorsal evenly and very gently convex; ventral outline more strongly convex than the dorsal, with a very slight angle at base of mandible; the margin of abdomen compressed, with sharp bony scutes; head moderate; snout rather long, 3.7 to 5 in head; eye small,

about equal to length of snout, except in very young, 3 to 4.4 (average for 22 specimens 3.53) in head; interorbital 2.95 to 5.8; mouth moderate, oblique, slightly superior, but not entering into the dorsal profile; maxillary broad, reaching about opposite middle of eye, 2.2 to 2.6 in head; cheek broad, its width greater than its depth; mandible slightly projecting, the tip not included in the upper jaw, but not entering into the general dorsal outline, its outline as in *P. pseudoharengus*; teeth as in *P. pseudoharengus*; gill rakers long and slender, increasing in number with age, young of

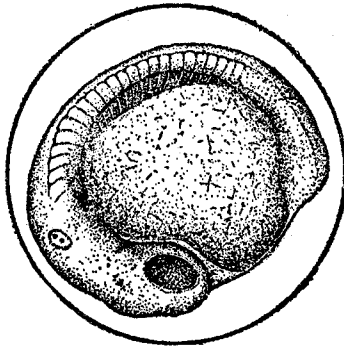


FIG. 45.—Egg with large embryo

40 to 50 millimeters in length, with 28 to 34 gill rakers on the lower limb of the first arch, adult specimens with 42 to 50 gill rakers; scales moderate, more or less deciduous: ventral scutes 19 to 22 in advance of ventrals and 13 to 16 behind ventrals, total number of scutes 33 to 36; dorsal fin rather small, its outer margin concave, the origin at least an eye's diameter nearer tip of snout than base of caudal; caudal fin forked, the lobes about equal; anal fin a little longer than the dorsal, but lower, its origin about equally distant from base of ventrals and base of caudal; ventral fins small, inserted equidistant from the base of pectorals and the origin of the anal; pectoral fins similar to the ventrals, but larger, 1.3 to 1.85 in head.

Color bluish above, sides silvery; upper rows of scales with more or less distinct dark lines in the adult; a dark spot at shoulder (this is rarely present in specimens less than 100 millimeters (4 inches) in length). Fins all plain, sometimes slightly

yellowish or greenish in life. Peritoneum black.

Numerous specimens, ranging from 20 to 295 millimeters ($\frac{1}{4}$ to $11\frac{1}{8}$ inches) in length, have been examined. This species is similar to the branch herring (*P. pseudoharengus*), the most outstanding difference being the color of the peritoneum, which is black in the present species and pale or silvery in the branch herring. Externally, the glut herring differs from the branch herring in being a more slender and elongate fish. It has a somewhat smaller eye, and the color of the back

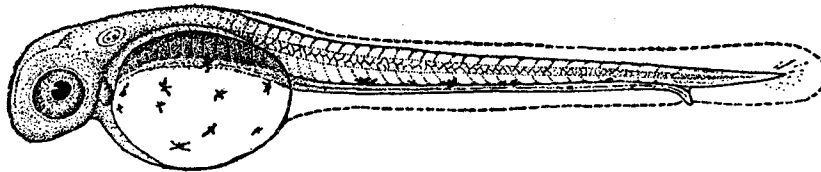


FIG. 46.—Newly hatched larva, 3.5 millimeters long

is bluish rather than grayish green, as in the branch herring. This difference in color is recognized by the fishermen and gives rise to the local names "blue herring" and "gray herring." All of the external differences mentioned, however, appear to vary, and occasionally intermediate specimens are found, which are difficult to separate without examining the peritoneum. The difference between the young and the adults of this species are not especially pronounced and are not unusual. The sexes are so similar that they are not readily distinguished externally.

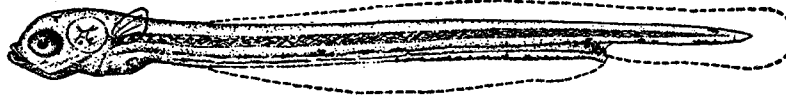


FIG. 47.—Larva 4 days old, 5.2 millimeters long

The habits of this fish are similar to those of the branch herring, and the remarks regarding the latter in general also apply to this fish. The glut herring, however, enters fresh water several weeks later than the branch herring. In the lower bay a few are caught with pound nets in March, the catch increasing toward the end of the month. In the first week of April, 1922, the pound nets at Lynnhaven Roads and Ocean View were catching the two species in the following ratio: Branch herring 60, glut herring 40. The peak of the catch of glut herring is usually taken between

April 1 and 20 in the lower bay. The numbers decrease throughout May, until after June 1 only stragglers are caught. At Havre de Grace notes made by the late William W. Welsh in 1912 record the first catch of glut herring on April 11 and the height of the run on about April 27. Of course, it is well known that the time of arrival and the height of the run vary somewhat from year to year, but in general the glut herring is expected in the lower Chesapeake region the first half of April and in the upper reaches of the bay during the last half of April. This species does not

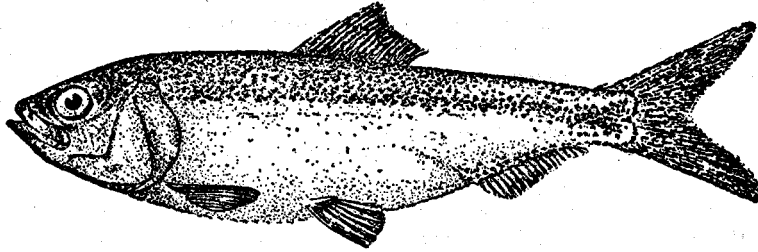


FIG. 48.—Young, 30 millimeters long

ascend fresh-water streams as far as the branch herring, and spawning takes place at a shorter distance from the sea. The greater part of the young, as in the branch herring, appear to pass through Chesapeake Bay and out to sea upon the approach of cold weather, but a few stop in the deeper waters of the bay during their first winter and very few apparently remain there for the second winter.

The rate of growth^{*} in the young of this species appears to be somewhat more rapid than in the branch herring. The size attained at a given age is quite uniform, as no difficulty was expe-

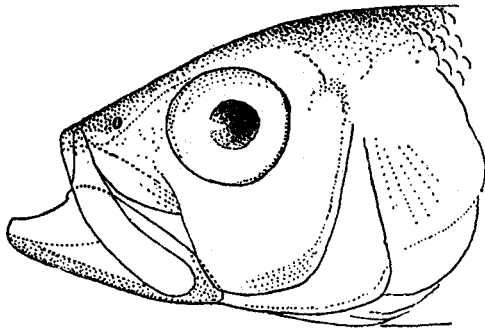


FIG. 49.—*Pomolobus xstivalis*. Note deep mandible and sharp angle on its upper margin

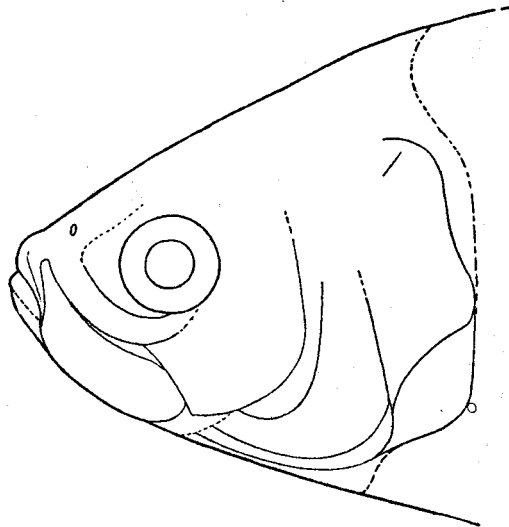


FIG. 50.—*Pomolobus xstivalis*. Note that mandible scarcely projects and that it does not enter dorsal profile

rienced in separating young fish into year groups. Specimens taken in March, for example, clearly fall into two separate lots, one group consisting of individuals that are in their first year and the other group comprising those in their second year. The uniformity in size of the young of a certain age suggests a short spawning period. The young of the branch herring, on the other hand, vary greatly in size, and much difficulty was experienced in separating into year groups catches taken

^{*} The eggs, embryology, and larval development of the glut herring are described by Kuntz and Radcliffe (1918, pp. 123 to 126, figs. 87 to 100).

in the bay on various dates. This large variation in size of young taken on the same date suggests a rather protracted spawning period.

A large number of young glut herring taken in fresh water, principally in 1912, had attained an average length of 28 millimeters ($1\frac{1}{8}$ inches) on July 1, 46 millimeters ($1\frac{1}{4}$ inches) on September 1, and 64 millimeters ($2\frac{1}{2}$ inches) on December 1. A decided upward jump takes place in the growth curve between the last lots taken in fresh water and those taken in the salt water of the bay. The reasons for this sudden upward curve are not definitely known and the subject needs further investigation. The two possible reasons that have occurred to us are (1) that growth is greatly exhaltated when the fish enters salt water; this explanation is rendered somewhat unlikely because of the cold winter weather; (2) it seems probable that the smaller individuals of the season's brood remain in fresh water later than the larger ones, and therefore the lots taken late in the fall in fresh water consist of fish that are either "runts" or hatched late in the season, whereas the catches in January and February from the bay consist of fish of more average growth. It seems altogether unlikely that the fish from the bay belong to a different year class. A limited number of specimens taken in the deeper waters of the bay had reached an average length of 82 millimeters ($3\frac{1}{4}$ inches) by February 1 and 90 millimeters ($3\frac{1}{2}$ inches) by April 1. A few individuals taken in Chesapeake Bay, which probably were in their second year, had attained an average length of 174 millimeters ($6\frac{7}{8}$ inches) on February 1.

The maximum length attained by the glut herring is about 380 millimeters (15 inches) and the weight 13 ounces. The average length of market fish, however, is only about 280 millimeters (11 inches) and the weight 7 ounces.

Length frequencies of 2,035 glut herring, Pomolobus æstivalis

[Measurements in millimeters, grouped in 5-millimeter intervals]

Total length, millimeters)	June		July		Aug.		Sept.		Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.		May	
	1-15	16-30	1-15	16-31	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-15	16-28	1-15	16-31	1-15	16-30	1-15	16-31
20-24		22																						
25-29		4																						
30-34																								
35-39		1																						
40-44																								
45-49																								
50-54																								
55-59																								
60-64																								
65-69																								
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180-184																								
185-189																								
190-194																								
195-199																								
200-209																								
Total		27		31		93	51	50	70	162	106	75			286	57	238	346	435				8	

The glut herring and the branch herring are not separated for the market, and the data and remarks concerning the commercial importance of the branch herring, therefore, also include the present species.

Habitat.—Nova Scotia to St. Johns River, Fla.

Chesapeake localities.—(a) Previous records: Many parts of the bay and virtually all streams tributary to the bay. (b) The numerous young in the present collection, ranging in length from 20 to 119 millimeters ($\frac{3}{8}$ to $4\frac{3}{8}$ inches), are from the following localities: Beam-trawl catches in many parts of the bay from Annapolis, Md., to Old Point Comfort, Va., including the Potomac River below Mathias Point, at depths ranging from 5 to 28 fathoms, January 15 to March 24, 1914, January 16 to March 12, 1916, January 22 to 26, 1921, February 14 to 19, 1922. Taken with seines in the Potomac River from Bryans Point, Md., to Lewisetta, Va., October 14 to November 11, 1911, June 17 to December 3, 1912, October 29, 1914, August 8, 1921; in the bay at Havre de Grace, Md., May 10, 1922, August 26, 27, 1921; Baltimore, May 4, 1922; Annapolis, Md., May 3, 1922; Love Point, Md., September 5, 1921; Buckroe Beach, Va., April 10, 1922.

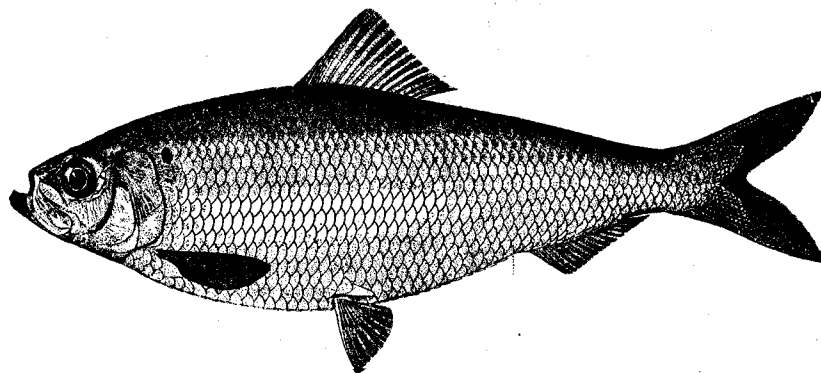


FIG. 51.—*Pomolobus pseudoharengus*. From a specimen 11.5 inches long

35. *Pomolobus pseudoharengus* (Wilson). Alewife; "Branch herring"; Big-eyed herring; "Herring"; "Gray herring"; "White herring".

Clupea pseudoharengus Wilson, Rees's Cyclopaedia, IX, no pagination and no date, about 1811; Philadelphia.

Pomolobus pseudoharengus Uhler and Lugger, 1876, ed. I, p. 158; ed. II, p. 135 (in part).

Pomolobus vernalis Goode, in McDonald, 1879, p. 14.

Clupea vernalis Bean 1883, p. 366.

Pomolobus pseudoharengus Jordan and Evermann, 1896-1900, p. 426, Pl. LXXI, fig. 189; Smith and Bean, 1899, p. 183; Evermann and Hildebrand, 1910, p. 158; Fowler, 1912, p. 51.

Pomolobus mediocris Evermann and Hildebrand, 1910, p. 158 (not of Mitchill).

Head 2.9 to 4.3; depth 2.8 to 4.15 (average for 22 specimens 3.23); D. 15 to 19 (usually 16 or 17); A. 17 to 21; scales 46 to 49. Body rather deep, compressed, slightly deeper in the adult than in young; dorsal profile from snout to dorsal fin gently and nearly evenly rounded; ventral outline more strongly convex than the dorsal, with a slight angle at base of mandible; the margin of the abdomen compressed and provided with strong, bony scutes; head rather short and deep; snout rather blunt, 3.5 to 5 in head; eye large, longer than snout, 2.6 to 4.15 (average for 22 specimens 3.12) in head; interorbital 4 to 6.45; mouth moderate, slightly superior; maxillary broad, reaching about opposite middle of eye, 2 to 2.65 in head; cheek broad, its width greater than its depth; mandible slightly projecting, the tip not included in the upper jaw but not entering into the general dorsal outline, its upper margin strongly elevated, with a prominent angle near the middle of its length; teeth very weak, present on premaxillaries and tip of lower jaw in the young, sometimes persisting in the adult; gill rakers rather slender, of moderate length, increasing in number with age, young 30 to 58 millimeters in length with 22 to 29 gill rakers on the lower limb of the first arch, specimens ranging from 158 to 284 millimeters with 33 to 40 gill rakers; scales of moderate size, cycloid, more or less deciduous; ventral scutes 19 to 22 in advance of ventrals and 11 to 15 behind ventrals, total number of scutes 30 to 35; dorsal fin rather small, its outer margin very slightly concave, the origin

usually slightly nearer tip of snout than vertical from end of base of anal; caudal fin forked, the lobes nearly symmetrical; anal fin a little longer than the dorsal, but lower, the anterior rays only slightly longer than the posterior ones, its origin nearly equally distant from base of ventrals and base of caudal; ventral fins rather small, pointed, inserted about midway between the base of the pectorals and the origin of the anal; pectoral fins moderate, similar to the ventrals but larger, 1.2 to 2 in head.

Color grayish-green with metallic luster above, sides silvery; a dark spot at shoulder (rarely developed in the young of less than 100 millimeters (4 inches) in length). Rows of scales with indistinct dark lines, which are present only in the adult, appearing somewhat later in life than the dark shoulder spot. Fins all plain, slightly greenish or yellowish in life; the dorsal and caudal with dusky punctulations; peritoneum pale.

Numerous specimens, ranging from 30 to 284 millimeters in length, have been examined. This species is recognized by the large eye (which is longer than the snout at all ages), by the deep body and by the pale peritoneum. The young of this species do not differ greatly from the adults, except that the body is scarcely as deep, the eye is proportionately larger, and the gill rakers are fewer in number. The sexes are very similar, but the dorsal fin in the male appears to be a little higher. The difference in size of the sexes, as shown by a limited number of weights and measurements, is not pronounced. The female, however, appears to reach a slightly greater length and weight.

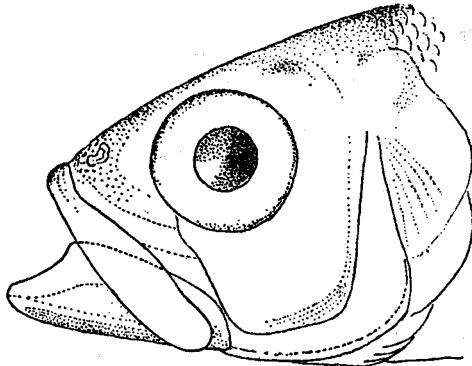


FIG. 52.—*Pomolobus pseudoharengus*. Note broad cheek bone and deep mandible with pronounced angle on its upper margin

In 12 stomachs examined, taken from fish ranging in length from 83 to 178 millimeters ($3\frac{1}{4}$ to 7 inches) examined by Linton, the principal food of the smallest specimens consisted of copepods; in the medium-sized and in the largest ones it consisted of Mysis. In 7 large fish, 2 stomachs were empty, 2 had fed wholly on Mysis, and 3 wholly on fish. The authors examined 6 stomachs of specimens taken in fresh water during the summer, ranging in length 50 to 70 millimeters, and found 2 stomachs empty, 2 fish had fed wholly on copepods, one contained a worm, and the smallest had fed on ostracods. Stomachs of five larger specimens, taken in salt water in the bay during March, ranging from 90 to 178 millimeters in length, contained Mysis only, and these had been eaten in great numbers.

In this species, as in the common shad, the ceca, connected with the intestine near the stomach, are very small or wanting in the young and become greatly developed with age.

This fish enters streams in the spring to spawn, and when this purpose is accomplished the adult again returns to the ocean, where most of its life is spent. The young remain in fresh water throughout the first summer of their lives, but with the approach of cool weather they gradually migrate to salt water, but they do not all leave the fresh or brackish water (of the Potomac River) until late in the fall, as specimens have been taken as late as November 11 at Bryans Point, Md., and at Riverside, Md., as late as December 3. The majority of the young evidently pass through Chesapeake Bay without stopping and migrate directly to the ocean, but we have specimens taken in the deeper waters of the bay throughout the winter months, indicating that at least some of them do not enter the ocean until they are a year or more old. Measurements of specimens indicate that a few fish may stay in the bay until they are 2 years old. The movements and the life history of the branch herring during the period or periods spent in the ocean are very imperfectly understood. "During the summer months enormous schools of full grown but sexually immature alewives migrate along the coast." (Bean, 1903, p. 201.) Further information concerning the fish after it enters the sea is wanting.

The branch herring generally reach fresh-water streams in the spring three or four weeks earlier than the glut herring and they also precede the first run of shad. In the Chesapeake drainage they usually arrive some time in March. This fish runs far upstream to spawn, fre-

quently entering small brooks only a few feet wide and a few inches deep. "The alewives are very prolific. In the Potomac River, 644 female branch herring yielded 66,206,000 eggs, an average of 102,800 per fish; and probably 100,000 eggs may be taken as a fair average for the species. The eggs are 0.05 inches in diameter, and are very glutinous when first laid, adhering to brush, ropes, stones, piling, and other objects. The hatching period is six days in a mean water temperature of 60° F." (Smith, 1907, p. 123.)

The young grow rapidly, reaching an average length of about 55 millimeters ($2\frac{1}{8}$ inches) by July 1, 65 millimeters ($2\frac{1}{2}$ inches) by September 1, and 70 millimeters ($2\frac{3}{4}$ inches) by December 1. The individuals that stop in Chesapeake Bay during the first winter of their lives appear to grow very rapidly (possibly the explanations given on p. 88 for *P. astivalis* apply to this species also) after entering the salt water, as specimens taken in the bay had attained an average length of about 105 millimeters ($4\frac{1}{8}$ inches) by February 1 and 120 millimeters ($4\frac{3}{4}$ inches) by May 1. Fish taken in Chesapeake Bay, which apparently were in their second year, had reached a length of about 140 millimeters ($5\frac{1}{2}$ inches) by October 1 and 165 millimeters ($6\frac{1}{2}$ inches) by March 1. It would appear that if this rate of growth is maintained the branch herring may reach its average maximum length of 11 inches in about four years.

Length frequencies of 1,967 branch herring, "Pomolobus pseudoharengus"

[Measurements in millimeters, grouped in 5-millimeter intervals]

Total length, millimeters	June		July		Aug.		Sept.		Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.		May	
	1-15	16-30	1-15	16-31	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-15	16-28	1-15	16-31	1-15	16-30	1-15	16-31
30-34	1	2																						
35-39	2	6																						
40-44	1	5																						
45-49	1	2		1																				
50-54	1	3		25	6	4		3																
55-59	1	1	4	25	14	8	8	9	15	6	2													
60-64				11	6	14	14	33	14	27	5	6	1											
65-69			1	10	2	13	18	28	11	21	21	37	3								1			
70-74				2	2	5	7	10	5	10	1	96	9									1		
75-79					1	4		4	4	1	37	6			1									
80-84						1		3	1	3	4				6		2	2	2	1				
85-89									2	1					15		2	1	6					
90-94															28		11	9	19					
95-99															36		14	25	31				1	
100-104										2					63		38	32	67		1			
105-109										1					44		35	29	48	1	2			
110-114															29		38	20	52	1				1
115-119									1						25		33	20	42				3	
120-124									1						25		16	12	25		3	1		
125-129									3						13		12	14	13	1	1	1		
130-134									1	1					11		8	10	14					1
135-139									1	2					9		7	10	14		1			
140-144									2		1					5		8	5	6	1		1	
145-149									1	1	1				3		6	5	12	1			1	
150-154									1	1	1				2		7	2	15		1			
155-159									1	1	1				3		8	2	8		1			
160-164									2						4		12	3	9	1				
165-169		1							2		1				4		9		3		1			
170-174									1		1				3		12		8					
175-179											1				2		5		4					1
180-184									1						1		1		1	1				
185-189									1						1			1	3		1			
190-194		1							1		1													
195-199															1				1					
200-204																			1					
205-209																								
210-214																								
215-219																								
220-224																								
Total	7	21	5	74	31	49	47	87	54	85	41	188	19		34	301		285	202	404	9	13	8	3

The maximum length attained by the branch herring is about 380 millimeters (15 inches) and the weight about 14 ounces. The average length of market examples, however, is only about 11 inches and the average weight is about 8 ounces.

The branch and glut herrings are both very abundant species in the Chesapeake region, probably occurring in about equal numbers. Since the branch herring arrive earlier than the glut herring, the earliest catches consist wholly of the former species, which is gradually replaced by the latter as

the season advances. The species are not separated for the market and are sold either as river herring or alewives; therefore, the available statistics include both species, and their relative abundance is judged only from the observations made of various catches. Observations made at Lynnhaven Roads, Va., from April 4 to 8, 1922, showed that the catch taken in pound nets consisted of 27 per cent branch herring and 43 per cent glut herring. At Lewisetta, Va., from April 24 to 28, 1922, the catch taken with pound nets consisted of 29 per cent branch herring and 61 per cent glut herring. The largest catches of herrings are made in the southern sections of the bay between March 20 and April 20, whereas in the vicinity of Havre de Grace, Md., at the head of the bay, the principal fishing season usually extends from April 10 to May 10.

Throughout Chesapeake Bay, during 1920, the alewives ranked first in quantity and second in value, the catch being 22,986,158 pounds, worth \$416,968.

In Maryland the alewives ranked first in quantity and third in value, the catch being 6,604,891 pounds, worth \$163,544. Of this amount, 87 per cent was caught in pound nets, 9 per cent in haul seines, 3 per cent in gill nets, and 1 per cent with other apparatus. The five leading counties, with respect to the pounds of alewives caught, were Talbot, 1,506,865; Cecil, 1,170,780; Dorchester, 595,482; St. Marys, 534,888; and Harford, 453,840.

In Virginia they ranked first in quantity and fourth in value, the catch being 16,381,267 pounds, worth \$253,424. Of this amount, 90 per cent was caught in pound nets and 10 per cent with seines, gill nets, fyke nets, and slat traps. The five leading counties, with respect to the pounds of alewives caught, were Northumberland, 5,726,586; Mathews, 3,057,900; Lancaster, 2,060,353; Elizabeth City, 1,120,000; and Gloucester, 1,068,800.

Somewhat over half of the herring catch is salted. In 1920, 1,456,300 pounds of salt herring were marketed by fishermen, and an additional 7,696,420 pounds were put up by wholesale and canning firms, making a total production of 9,152,720 pounds, valued at \$291,948. Salting fish and canning roe is engaged in only during the height of the run. As a rule, vegetable canneries are utilized, as very little added equipment is necessary to handle the fish. The greater part of the salting and canning is done at Havre de Grace and Oxford, Md., and Lewisetta and Gwinns Island, Va. One cannery at Havre de Grace during most of April, 1922, utilized about 125,000 herrings per day.

The prices that the fishermen receive fluctuate considerably from year to year and during the same season. During the 1920 season the average price was slightly less than 2 cents per pound, or about \$8 for 1,000 fish. During 1922 the prices were lower and the salting houses paid \$5 per thousand fish during the earlier part of the season, but this price had dropped to \$1.50 by the middle of April. All the salting establishments employed run boats for collecting the fish from the fishermen, and many fishermen preferred to dispose of their catches in this way, as it obviated packing and shipping to market. The market prices always were higher than the price paid by run-boat operators. The difference in the prices, however, was somewhat offset by the cost of packing and shipping.

Comparison of lengths and weights

ADULT FISH

Locality	Date	Sex	Length, inches	Average weight, ounces
Havre de Grace, Md.	Apr. 30, 1912	Females	11 $\frac{3}{4}$ to 12 $\frac{1}{4}$ (5 fish)	9.6
		Males	10 $\frac{1}{2}$ to 11 $\frac{1}{2}$ (7 fish)	8.0
	May 9, 1922	Undetermined	10 $\frac{1}{4}$ to 13 (14 fish)	7.5
Lewisetta, Va.	Apr. 24, 1922	Female	11 $\frac{1}{4}$ (1 fish)	9.6

YOUNG FISH

Solomons, Md.	Oct. 28, 1921	Undetermined	4 $\frac{1}{2}$ to 4 $\frac{3}{4}$ (2 fish) 5 to 5 $\frac{3}{8}$ (2 fish)	0.55 .8
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Habitat.—Nova Scotia to North Carolina. Landlocked in Lakes Cayuga and Seneca, N. Y., and also present in Lake Ontario. "In Lake Ontario, since the introduction there of the shad, the alewife has become so plentiful as to cause great difficulty to fishermen, and its periodical

mortality is a serious menace to the health of people living in the vicinity. The belief is that the fish were unintentionally introduced with the shad." (Bean, 1903, p. 200.) It is supposed to have reached Cayuga and Seneca Lakes in a natural way.

Chesapeake localities.—(a) Previous records: From virtually all streams tributary to Chesapeake Bay. (b) The numerous young in the present collection, ranging in length from 30 to 165 millimeters, are from the following localities: Beam-trawl catches in many parts of the bay, from Annapolis, Md., to Old Point, Va., including the Potomac River below Cedar Point, at depths ranging from 5 to 28 fathoms, January 15 to April 28, 1914, January 16 to April 25, 1916, January 22 to January 27, 1921, and February 17 and April 20, 1922. Taken with seines in Potomac River from Washington, D. C., to Lewisetta, Va., September 21, 1911, June 7 to December 3, 1912, and October 24 and 25, 1921; and in the bay from Havre de Grace, Md., to Lynnhaven Roads, Va., June 22 to November 21, 1921, and April 8 to October 27, 1922.

Comparative statistics of the alewife product of Maryland and Virginia for various years from 1880 to 1921

Years	Pounds	Value	Years	Pounds	Value
1880.....	16, 129, 372	\$215, 967	1901.....	27, 660, 601	\$206, 732
1887.....	15, 463, 905	118, 858	1904.....	29, 088, 836	228, 715
1888.....	17, 964, 779	150, 660	1908.....	66, 690, 000	328, 000
1890.....	30, 408, 692	235, 467	1909.....	51, 425, 300	283, 874
1891.....	28, 432, 335	225, 150	1915.....	28, 621, 710	297, 729
1896.....	29, 564, 922	189, 074	1920.....	23, 736, 788	436, 448
1897.....	30, 828, 969	194, 294	1921.....	25, 339, 009	390, 529

NOTE.—The catch of alewives in these States, outside of the Chesapeake Bay, is included for some years but is practically negligible.

26. Genus *ALOSA* Linck. The shad

The genus *Alosa* is described as differing from *Pomolobus* in having the cheeks deeper than long, the upper jaw deeply indented anteriorly, and the toothless jaws of the adult. These differences separate the genus very satisfactorily from *P. æstivalis* and *P. pseudoharengus*, but in *P. mediocris*, with the exception of the toothless jaw of the adult *Alosa*, these differences become very slight or disappear; for in *P. mediocris* the cheeks are at least as deep as long and an indentation in the upper jaw is distinctly present. It is the opinion of the present authors, therefore, that the genus *Alosa* is scarcely tenable.

36. *Alosa sapidissima* (Wilson). Shad.

Clupea sapidissima Wilson, in Rees's New Cyclopedia, IX, no pagination and no date (about 1811); Philadelphia. Bean, 1883, p. 366.

Alosa sapidissima Uhler and Lugger, 1876, ed. I, p. 157; ed. II, p. 133; Jordan and Evermann, 1896–1900, p. 427, Pl. LXXII, fig. 191; Smith and Bean, 1899, p. 184; Fowler, 1912, p. 51.

Head 3.2 to 4.3; depth 2.7 to 3.9; D. 17 to 19; A. 19 to 23 (usual number 21 or 22); scales about 52 to 64. Body elongate, compressed, deeper in adult than in young, average depth in length to base of caudal of young of 35 to 100 millimeters, 3.5, adult females about 2.75; dorsal profile nearly straight on head, gently convex from nape to dorsal, ventral outline gently and evenly rounded, the abdomen compressed, with sharp ventral edge, provided with scutes; head rather small, low, and comparatively long; snout slightly tapering, 3.2 to 4.7 in head; eye 3 to 5.95; interorbital 3.95 to 5.85; mouth rather large, terminal; maxillary broad, reaching middle of eye in young (50 millimeters long), to or a little beyond posterior margin of eye in adults, 1.85 to 2.7 in head; cheek deeper than long, narrower below than above; mandible not projecting, included in upper jaw and not entering into the dorsal profile, its upper margin rather gently elevated, without a prominent angle near the middle of its length; teeth in the adult wholly wanting, the young with small, weak teeth on the anterior part of the jaws; gill rakers rather numerous, long and slender, increasing greatly in number with age, specimens 35 to 70 millimeters in length with 26 to 31 gill rakers on the lower limb of the first arch, specimens 110 to 180 millimeters long with 34 to 41, adults 413 to 580 millimeters in length with 62 to 76 gill rakers; scales of moderate size,

deciduous in young and to a lesser extent in the adult; ventral scutes, 20 to 24 in advance of ventrals (usual number 21 or 22) and 12 to 16 behind ventrals (usual number 14 or 15), total number of ventral scutes 32 to 39 (usual number 35 to 37); dorsal fin rather small, its outer margin slightly concave, the origin considerably nearer tip of snout than base of caudal; caudal fin deeply forked, both lobes pointed; anal fin somewhat longer than the dorsal, the anterior rays only slightly longer than the posterior ones, its origin at least twice the diameter of the eye behind vertical from the end of the dorsal; ventral fins rather small, pointed, inserted a little in advance of the vertical from middle of base of dorsal; pectoral fins much larger than the ventrals but similar in shape, 1.4 to 1.7 in head.

Color greenish, with metallic luster above, sides silvery; a dark spot at shoulder, occasionally followed by smaller ones, rarely with a second parallel row somewhat above the median line of side. Fins all pale to slightly greenish, the dorsal and caudal somewhat dusky in the larger specimens, darkest at tips. Peritoneum pale.

Leim (1924, p. 224), who made an exhaustive study of the shad in the Bay of Fundy, gives the following counts for rays, scutes, and vertebrae (the predominating numbers are placed in parentheses): Dorsal rays 15 to 19 (17 or 18), 676 fish; anal rays 18 to 24 (20 to 22), 317 fish; pectoral rays 14 to 18 (15 to 17), 287 fish; pelvic (ventral) rays 8 to 10 (9), 277 fish; anterior ventral scutes 19 to 23 (20 to 22), 315 fish; posterior ventral scutes 12 to 19 (16 or 17), 653 fish; vertebrae 51 to 59 (56 or 57), 170 fish. These counts vary somewhat from those taken of Chesapeake Bay

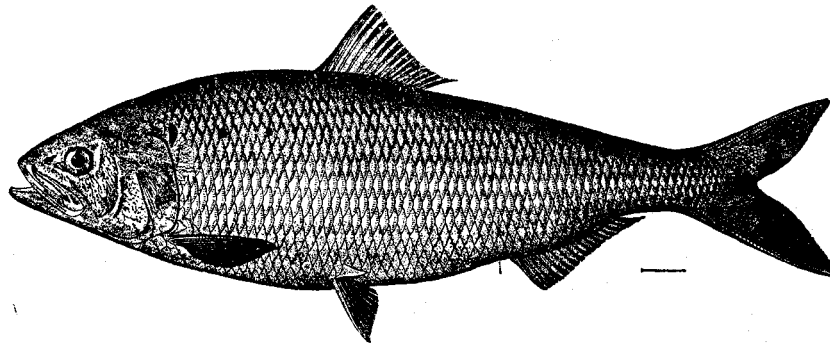


FIG. 53.—*Alosa sapidissima*

shad. This, however, is only to be expected, as Leim, who examined a large number of fish, found a slight variation even among the several localities of the Bay of Fundy where his specimens were obtained.

Numerous small specimens, 21 to 115 millimeters ($\frac{5}{8}$ to $4\frac{1}{2}$ inches) in length, taken in fresh water, are at hand. We also have 26 specimens contained in various small lots, of different localities and dates, taken in salt or brackish water during the fall and winter, ranging from 97 to 243 millimeters ($3\frac{7}{8}$ to $9\frac{1}{2}$ inches) in length, and three adult females. The young shad is not readily distinguished from the young of the genus *Pomolobus*. It is particularly close to the hickory shad, (*P. mediocris*), from which the young are difficult to separate. In the common shad the lower jaw, however, is included in the upper; it does not protrude and it does not enter into the dorsal profile. In the hickory shad the lower jaw projects strongly and the tip of it enters into the dorsal profile. Another and more pronounced difference is evident in the number of gill rakers supported by the lower limb of the first arch. The number of gill rakers increases greatly with age in at least some of the Clupeidae, but in our series there is no overlapping, the common shad always having more gill rakers than the hickory shad. The range in the number of gill rakers on the lower limb of the first arch for the common shad in specimens ranging from $1\frac{1}{2}$ to 23 inches in length is 26 to 71. In the hickory shad in specimens $6\frac{1}{4}$ to 12 inches long it is from 18 to 22. The difference is more evident when specimens of the same size are compared. A common shad 160 millimeters long, for example, has about 40 gill rakers on the lower limb of the first arch, whereas a hickory shad of the same length has only about 18. From the other species of *Pomolobus* the

young shad may be separated by the much narrower and proportionately deeper cheek and by the much lower and broader angle near the middle of the sides of the upper margin of the mandible. The young shad does not differ greatly from the adult, except that the body is more slender, the gill rakers much fewer, and the dark spot at the shoulder is undeveloped. The sexes are very similar, except that the female reaches a larger size than the male.

The young shad, according to published accounts, feed on small crustaceans, insects, and insect larvæ, as well as on small fish. This statement was verified through the examination of 14 stomachs. Stomachs of specimens ranging from $1\frac{3}{4}$ to $2\frac{3}{8}$ inches in length, taken in fresh water, had fed mainly on adult insects but also on ostracods. Specimens somewhat larger, ranging from 4 to 6 inches in length, taken in salt or brackish water, had fed almost wholly on small crustaceans (Mysis), but one stomach contained a small amount of plant tissue and another contained fragments of a small fish.

Little or no food has been found in the shad while they were migrating up rivers. Various investigators, however, have examined the stomachs of adult fish caught in the sea or at the mouths of estuaries and have found food. An adult female taken in the southern part of Chesapeake Bay early in December, 1921, and examined by us, had the stomach gorged with parts of plants, consisting not only of the softer parts but also of hard stems. Fragments of a molluscan shell also were present. Perley (1851, p. 139) found that the shad in the Bay of Fundy fed on shrimp and "shad worm." Mordecai (1860, p. 278) examined shad stomachs from the vicinity of Savannah, Ga., and as a result states that "shad feed and fatten on marine fuci and microscopic organisms that are parasitically attached." Leidy (1862, p. 2) obtained a shad in a market and upon opening it found in its stomach nine small fish, which were identified as follows: Three *Hydrargyra swampina*; five *Pæcilia latipinnis*, and one *Cyprinodon ovinus*. As these species inhabit fresh or slightly brackish water, and as the shad was probably received in Philadelphia, it is likely that it was caught in Delaware Bay. Leidy (1868, p. 228) examined a shad caught in the fall, probably off the coast of New Jersey or in Delaware Bay, and found in its stomach 30 sand launces (*Ammodytes americanus*), 2 to 4 inches long. Baird (1874, p. LVIII) says that in the sea the food of the shad consists "of worms, small fishes, and most largely of minute crustaceans, especially of the genus *Mysis*." Huyler (1876, p. 233) examined the stomachs of 15 shad caught in the North River near Fort Lee, N. J., on May 5, 1874, and found them containing many young shrimp about half an inch long. One of these stomachs contained several hundred shrimp. Prime (1876, p. 138) reports the capture of several shad (at least one with full roe) with artificial flies in the Connecticut River, thus indicating that at times the shad will feed just prior to spawning. It is of interest to note that these fish were caught on July 1, at the very end of the spawning season for that region. Smith (1896, p. 405) quotes Seth Green as saying that sand fleas [*Gammarus*?] are the principal food of the old shad in the Atlantic. Bean (1903, p. 207) says that the shad coming in to spawn will sometimes take the artificial fly and live minnows. Willey (1923, p. 313) examined many shad from the Nova Scotian coast of the Bay of Fundy and found the stomachs to contain chiefly copepods (*Acartia*, *Temora*, and other genera), mysid shrimp, and the larval stages of barnacles. Leim (1924) examined the stomachs of about 350 shad caught in Scotsman Bay, Bay of Fundy, during 1920 and 1922, consisting of mature and immature fish. Copepods formed the chief food for the smaller shad, but were of lesser importance in the diet of fish longer than 40 centimeters (16 inches). Mysids, however, while eaten sparingly by the younger fish, formed the chief constituent of the food of the adult shad. Copepods and mysids together formed about 90 per cent of the food of the shad of all sizes. Among the foods of lesser importance were ostracods, amphipods, isopods, decapod larvæ, insects, mollusks, algæ, fish eggs, and fish. Bigelow and Welsh (1925, p. 117) found adult shad taken in the Gulf of Maine in summer packed full of copepods (chiefly *Calanus*).

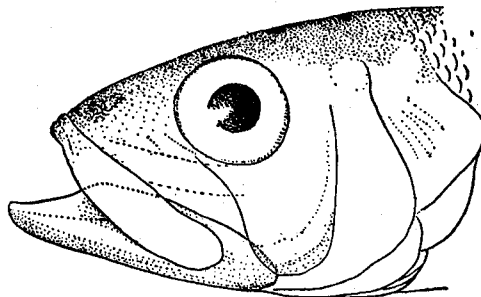


FIG. 54.—*Alosa sapidissima*. Note narrow, deep cheek bone and rather long, slender mandible without a pronounced angle on its upper margin

The fish examined by Bigelow and Welsh were taken far enough out in the Gulf of Maine to be removed from the influence of bay or river, and it is probable that their stomach contents show more truly than any of the other records given in the foregoing list the sort of food eaten by the shad at sea. These stomach examinations, therefore, justify Bigelow and Welsh's statement that the shad is primarily a plankton feeder.

The fact that adult shad in the sea are known to feed partly on mysid shrimps (bottom dwellers), on bottom-dwelling amphipods, etc., and on algæ is of considerable importance, as it suggests that part of a shad's life, perhaps a considerable part, is spent near the bottom of the sea. This may explain why so few shad are caught in the open sea south of Cape Cod. In the Gulf of Maine, however, large catches of shad are often made near the surface with purse seines, and it may be that in this region an abundant supply of food in the upper stratum of water lures the fish within reach of the nets. A change in the diet of the shad with age is suggested by the presence of numerous long cœca connected with the intestine near the stomach, which are very small or wanting in the young.

The life history of the shad is not well understood. It enters bays and rivers of the Atlantic coast of the United States in the spring, reaching the southern streams much earlier than the northern ones, and it ascends to fresh water for the purpose of spawning. The shad may spawn anywhere, but it appears to prefer shallow flats in rivers near the mouths of creeks. The fish are paired, swimming side by side, while spawning. The eggs are cast loose in the water, quickly sinking to the bottom, where many doubtlessly find unfavorable ground and fail to hatch.

The shad enters Chesapeake Bay in March, the date of arrival varying from year to year, and, with the exception of a few stragglers, they are gone again by the 1st of June. In 1921 a few shad were taken in pound nets in Chesapeake Bay throughout June and July and again during the latter part of November and early in December. These small and rather unusual fall runs, which occur only occasionally, naturally excite considerable interest. Whether such shad have remained in the inshore waters since spring, or whether they represent a new run from the sea is not definitely known; but inasmuch as extensive collecting in the inshore waters during the summer months has never brought an adult shad to light, it appears more reasonable to believe that they come from the sea. A female 17¼ inches long, taken on December 5, 1921, was preserved and critically examined in the laboratory and found to agree in all respects with the individuals of the spring run, except that it was smaller than the average size of the spring run of roe shad. This particular shad was full of eggs, which evidently were nearly mature. Whether or not the shad that constitute the fall runs usually are gravid is not known to the authors, but if this were the case the reason for their migration toward fresh water evidently would be the same as for the spring run—viz, for the purpose of reproduction. When the shad first arrive the males, or "buck shad," are greatly in the majority, but later in the season the females, or "roe shad," are the more numerous.

Spawning takes place soon after the fish reach fresh water. The eggs are relatively large after impregnation, measuring about 3 millimeters ($\frac{1}{8}$ inch) in diameter. The average number of eggs produced by a female, according to Smith (1907, p. 127), is from 25,000 to 30,000, but there are records of over 100,000 and in one case of 156,000 eggs having been taken from one fish. The period of incubation varies from six days and four hours in an average water temperature of 57.2° F. to a little less than three days in an average temperature of 74° F. (Ryder, 1884, p. 796). It is not considered an advantage, however, either to retard or to hasten hatching unduly, as a very long period of incubation may result in a proportionately smaller hatch and a very short incubation period yields weak fry. The average hatching period at temperatures that prevail during normal shad seasons varies from about six to ten days.

Although shad usually deposit their spawn in fresh water, recent studies by Leim (1924, p. 264) in the Bay of Fundy have shown that "the optimum conditions for the development of the eggs and larvæ up to the end of the period of yolk-sac absorption were a temperature of about 17° C., a salinity of about 7.5 per mille, and darkness." This is a most important finding, as virtually all shad hatching heretofore has been done in fresh water and largely in comparatively bright light.

Leach (1925, p. 485) reared shad successfully in a fresh-water pond at Washington, D. C., and in October, at the age of 5 months, transferred them to brackish-water aquaria (increasing the density of the water gradually from 1.005 to 1.018), in which they continued to thrive. Others of the same lot, transferred to fresh-water aquaria, died within three days.

The young when hatched are scarcely 10 millimeters ($\frac{3}{8}$ inch) in length, but they grow rapidly, reaching an average length of about 47 millimeters ($1\frac{7}{8}$ inches) during the first half of July (computation based on 74 specimens taken from the Potomac River at Bryans Point, Md., on July 2 and 9, 1912); 66.5 millimeters ($2\frac{5}{8}$ inches) by the last half of August (computation based on 5 specimens taken at Havre de Grace, Md., August 19, 1921, and also 30 specimens taken at Bryans Point, Md., August 23 and 30, 1912); and 70 millimeters ($2\frac{3}{4}$ inches) by the last half of October (computation based on 138 specimens taken in the Potomac River at Bryans Point, Md., on the following dates: October 20, 1909, October 21, 1910, October 21, 22, and 28, 1911, and October 19 and 23, 1912).

The migration of the young shad to salt water begins with the approach of cool weather, but it is not until near the end of November or the beginning of December that all the young shad have left the fresh waters. The foregoing statement is based on investigations made on the Potomac River by Lewis Radcliffe and the late William W. Welsh. It is evident from the collections at hand that some of the young shad may remain in the salt water of the bay until they are a year or more of age, as specimens were taken on the following dates: January 15, 17, and 19, 1916, February 18 and 21, 1916, and March 6 and 21, 1916. Eight shad, taken in January, 1916, had an average length of 108 millimeters ($4\frac{1}{4}$ inches); 3 taken in February, 1914, average 114 millimeters ($4\frac{1}{2}$ inches); 10 specimens taken in March, 1916, average 142 millimeters ($5\frac{5}{8}$ inches); and 2 specimens taken in May, 1922, average 152 millimeters (6 inches). Two specimens taken in November (one in 1912 and the other in 1921), having lengths of 149 millimeters ($6\frac{1}{8}$ inches) and 243 millimeters ($9\frac{1}{2}$ inches), may be in their second year, as they are very much larger than other specimens taken during the same month, although we are unable to observe anything in the structure of the scales that suggests a "winter ring."⁶ We are aware that there are published accounts of shad having attained, under especially favorable circumstances, a length of 6 or 7 inches, or in one instance of 9 inches (Smith, 1907, p. 127), at the age of 7 months. At Washington shad placed in ponds with an abundant supply of young carp for food attained a length of 6 inches by early November, but shad kept in an aquarium at the Bureau of Fisheries in Washington attained a length of less than 4 inches at the age of 1 year. Bean (1903, p. 208) states that "Nets set offshore in Gravesend Bay in the fall frequently inclose large quantities of young shad, sometimes a ton and a half at one time, during the migration seaward * * *. The fish are usually about 6 to 8 inches long." Bean, no doubt, assumed that these fish were the young of the last spawning season. However, in view of the fact that Chesapeake fish are only about 3 inches long in late fall, it is our opinion that these 6 to 8 inch shad probably were in their second year. As there are no "connecting links" between our two individuals ($6\frac{1}{8}$ and $9\frac{1}{2}$ inches) already mentioned and 140 other individuals at hand, taken during November, the largest of which is only 117 millimeters ($4\frac{1}{2}$ inches) long, the question naturally rises as to whether or not these specimens belong to an older class. The growth of the shad apparently is not noticeably retarded by the approach of cold weather, and it appears to continue throughout the winter. The limited number of specimens taken during the winter probably are too few to permit of definite conclusions, but if the rate of growth should be even slightly more rapid during the winter than during the summer, as indicated by the specimens at hand, an explanation for the apparent absence of definite "winter rings" on the scales of adult shad becomes evident. (The suggestions on p. 88, relative to the sudden upward bend in the growth curve of *P. æstivalis*, may apply to the shad also.) No specimens of young shad, except fry, were taken during the present investigations from April to October, both inclusive. The extensive collecting that was done shows quite conclusively that a few of the young shad spend the first winter of their lives in the salt water of the bay, and furthermore, that if any at all remain until they are more than a year old it is only a rare straggler.

⁶ For recent works on the age determination of the shad see "Age of shad (*Alosa sapidissima* Wilson) as determined by the scales," by N. Borodin. Transactions, American Fisheries Society, fifty-fourth annual meeting, Quebec, Canada, Sept., 1924 (1924), pp. 178-184, 6 figs. Hartford. Also, "A confirmation of Borodin's scale method of age determination of Connecticut River shad," by R. L. Barney. *Ibid.*, pp. 168 to 177, 4 figs.

Length frequencies of 807 shad, "Alosa sapidissima"

[Measurements in millimeters, grouped in 5-millimeter intervals]

Total length, milli- meters	June		July		Aug.		Sept.		Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.		May	
	1-15	16-30	1-15	16-31	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-15	16-28	1-15	16-31	1-15	16-30	1-15	16-31
20-24		5																						
25-29	2	12																						
30-34	11	14	3																					
35-39	5	15	11	8																				
40-44	4	26	17	5																				
45-49		16	12	11	3																			
50-54		3	17	20	8		4			2														
55-59		8	15	9	10	4	8	4	1	9														
60-64		6	1	2	5	10	22	5	11	17	1	1												
65-69		1	1	4	3	8	11	8	32	21	7	1												
70-74				2	2	12	6	8	21	40	21	2												
75-79					1	1	1	2	17	21	36	9												
80-84								3	5	9	23	6												
85-89									1	12	5	2											1	
90-94									1	1	3	1												
95-99										1	1	1												
100-104																1		1						
105-109																1								
110-114									1							1								
115-119										1	1					1								
120-124																1								
125-129																								
130-134																								
135-139																								
140-144																								
145-149																								
150-154																								
155-159																								
240-244																								
Total	22	106	77	61	32	35	53	31	88	137	103	37	2		7		3		10				3	

It is still a mystery, at least south of the New England coast, in what part of the sea the shad spends its life after it leaves the rivers and bays and until it again returns to spawn. To our knowledge no shad ever have been captured in the open sea off Chesapeake Bay, although menhaden purse seines are used in this region throughout the summer and fall. In the Gulf of Maine, however, adult shad not only are present (at times in abundance) from October until into December, but, according to Bigelow and Welsh (1925, p. 116), schools of immature shad from 1 foot long and one-half pound in weight up to 2 or 2½ pounds are reported every year at Provincetown for a short period in June. These authors report the capture of numbers of shad about 14 inches in length in the traps at Magnolia and Beverly from June 20 to July 6, 1921.

Atkins (1887, p. 684) reports large numbers of immature shad feeding about the bays and mouths of rivers along the coast of Maine during the summer after the main body of spawning fish had ascended the rivers. These immature so-called sea shad belonged to the group ranging from about one-half to 2½ pounds in weight. Up to the present day these immature shad are caught every year along the New England coast, although the quantities taken now, in keeping with the reduced numbers of adult fish, are much smaller than they once were. Our only knowledge of the shad from the time (late in the fall of the year) the young leave the rivers and bays in which they were hatched until they return as mature spawning fish is obtained from the immature fish, probably 2 to 3 years old, that are found during the summer, as already stated, in fairly large numbers along the shores of the Gulf of Maine and in smaller numbers south of Cape Cod.

Shad make their first appearance on the Atlantic coast in the St. Johns River, Fla., where they are first seen late in November and remain until March. It is extremely improbable that adult shad present in the Gulf of Maine in November and December could migrate to Florida and arrive there within the short period that would be necessary if they were to form part of the early winter catch of the St. Johns River. Stevenson (1899, p. 106), who made a study of the shad fisheries of the Atlantic coast, believed that the shad have a bathic migration rather than one toward and away from the Equator. The theory that shad migrate north and south along the Atlantic coast appears not to be as tenable as that they probably move off into deeper water of suitable temperature as

winter approaches and remain somewhere near the general vicinity of the rivers in which they were hatched and which they will ascend to spawn.

The shad received attention early by fish culturists, but it was not until 1867 that a hatching apparatus that proved successful was perfected. The United States Fish Commission first began hatching shad on the Connecticut River at South Hadley Falls, Mass., in 1872. In the following year this commission hatched 95,000 young shad on the Potomac River at Washington, D. C. This was the beginning of shad-hatching operations in the Chesapeake drainage. In 1875 the fish commission of Maryland also undertook the hatching of shad. Similar action was taken by Virginia a few years later, and the hatching of shad has been continued from year to year by the Federal Government and more or less intermittently by Maryland and Virginia.

Many millions of young shad have been hatched and liberated in the streams flowing into Chesapeake Bay, but this fish has not been reestablished in its former abundance. In fact, it is evident from statistics that a more or less fluctuating decline is taking place. (See table of comparative statistics.) In interpreting the statistics it is necessary to remember that larger and more effective fishing apparatus has been used from year to year and that, therefore, the reduction in the abundance of shad very probably is greater than the figures given would indicate. This decline in the abundance of shad while millions of young were being liberated no doubt is attributable mainly to overfishing and to pollution in the streams. Many of the gravid shad are taken in the bay before they reach fresh water, and those that are successful in entering streams must follow a maze to escape the numerous nets set in the rivers and in order to reach their spawning grounds. A boat trip on the lower part of Chesapeake Bay during the shad season will convince the most skeptical that it is astonishing that any shad at all reach their spawning grounds. In some of the rivers, at least, there is great danger that pollution is so great that the eggs produced will fail to hatch, or, if they do hatch, that the fry may not be able to survive. Further restrictions concerning the use of nets, the placement of obstructions in rivers, and the discharge of refuse and wastes into streams are undoubtedly necessary if the shad is to be maintained as an important commercial species.

Many experiments in transplanting the shad to waters in which it was not native were made by the United States Fish Commission when hatching operations were first undertaken.

Fry were liberated in various streams in the Mississippi Valley, also in several lakes, including the Great Lakes, in Bear and Jordan Rivers (both tributary to Great Salt Lake, Utah), and in the Sacramento River, Calif., from whence they descended to the Pacific Ocean. Only the last-mentioned introduction has proved successful, and large numbers of shad annually ascend the streams of the Pacific slope of the United States. However, on the Pacific coast this fish is not as highly regarded for food as it is on the Atlantic, and it is being shipped to eastern markets (including Baltimore), where it finds a ready sale.

The shad is the most valuable food fish caught in Chesapeake Bay, its value in 1920 being \$1,482,294, or more than the combined value of the four next most important species—namely, alewives, croakers, squeateagues, and striped bass. It ranked third in number of pounds caught (9,074,333), being exceeded only by the alewives and the croaker.

In Maryland it ranked second in quantity and first in value, the catch being 593,573 shad, weighing 1,816,346 pounds, worth \$344,110. Of this amount 53 per cent was taken in pound nets, 43 per cent in gill nets, 3½ per cent with seines, and one-half of 1 per cent with other apparatus. The three counties having the largest catches were Dorchester, with 348,883; Talbot, with 328,543; and Kent, with 307,300 pounds.

In Virginia it ranked third in quantity and first in value, the catch being 2,199,390 shad, weighing 7,257,987 pounds, worth \$1,138,184. Of this amount, 76 per cent was taken in pound nets, 23 per cent in gill nets, and 1 per cent in seines and fyke nets. The three counties credited with the largest catches were Mathews, with 2,295,730; Northumberland, with 1,291,488; and Lancaster, with 526,129 pounds.

In the Southern parts of the bay pound-net fishing is begun about March 1, and by March 15 virtually all the nets are set for the expected run of shad. Small quantities are taken early in March. The heaviest catches, however, are made between March 20 and April 20. The catch then declines, and after May 10 only small numbers are taken. However, it is not unusual to catch a few stragglers until late in June. In the vicinity of Havre de Grace, Md., the heaviest run

occurs during April. At this place pound nets are set only for shad and herring, the runs of these fish being over by the end of May, when fishing usually ceases for the year. Two of the best catches made by a set of nets in 1922 occurred on April 10, one at Ragged Point, Va., lower Potomac River, where 3,650 shad were taken in 2 nets, and the other at Cheapeake Beach, Md., where 4,600 shad were taken in 3 nets.

Shad are always packed and shipped in the fresh state, and facilities are available for bringing the fish to the market and the consumer in a remarkably short period of time. Fishing is done early in the day, usually at slack tide, and the fish at once are brought ashore to be packed in boxes and shipped on the first outgoing boat or train. Some fishermen dispose of their catch to "run boats," which anchor in convenient localities and which are fully equipped for this kind of trade. The fish are paid for in spot cash after being counted or weighed, and are packed loosely in the hold according to sex, the roe shad and buck shad being separated. Unless the catch is very small a run boat seldom waits for a second day's fishing but makes a rapid run to its home port, where the fish are properly packed and forwarded to the various markets. Many fishermen prefer to trade with the run-boat buyers as this relieves them of the trouble of packing and shipping their catches and brings prompt payments.

The maximum weight attained by shad on the Atlantic coast is about 12 pounds, but on the Pacific the shad is said to average 1 pound heavier, and a maximum weight of 14 pounds has been reported. A series of 21 female (roe) and 35 male (buck) shad from the Chesapeake region was measured and weighed. The female averaged 576 millimeters ($22\frac{3}{4}$ inches) in length and 6 pounds 5 ounces in weight, while the males averaged 500 millimeters ($19\frac{3}{4}$ inches) and 3 pounds 11 ounces, showing that the females of this lot averaged 2 pounds 10 ounces heavier than the males. The general run of female shad in the Chesapeake region weigh from 4 to $5\frac{1}{2}$ pounds and the males from $2\frac{1}{2}$ to 4 pounds.

Weight of various-sized fish, according to sex

Number of specimens measured	Length ¹	Weight ²		Number of specimens measured	Length ¹	Weight ²	
MALE	Inches	Pounds	Ounces	FEMALE	Inches	Pounds	Ounces
2.....	14	2	4	3.....	18	3	11
2.....	15	2	4	4.....	20	4	9
13.....	16	2	4	8.....	21	4	12
12.....	17	2	5	4.....	22	5	8
10.....	18	2	14	9.....	23	6	4
8.....	19	3	5	5.....	24	6	9
5.....	20	3	9	3.....	25	7	14
5.....	23	5					

¹ The fish measured have been grouped by inches for convenience; that is, if the specimen was nearer 14 inches in length than 15 inches, it was considered a 14-inch specimen.

² The weights given are the average of all fish of any one length group.

Habitat.—Gulf of St. Lawrence to Florida. (The shad occurring in the Gulf drainage is here considered as a separate and distinct species.)

Chesapeake localities.—(a) Previous records: From virtually all streams tributary to Chesapeake Bay. (b) The numerous young in the present collection, ranging in length from 21 to 243 millimeters ($\frac{5}{8}$ to $9\frac{1}{2}$ inches), are from the following localities: Beam-trawl catches, Sandy Point, Md., November 18, 1912; Barren Island, Md., to Smith Point, Va., January 19 to March 22, 1914; Oxford, Md., November 16, 1921; Hampton Roads, Va., January 15 and March 6, 1916, at depths ranging from 9 to 27 fathoms. Taken with seines: Havre de Grace, Md., August 19, 1921; Sassafras River, May 10, 1922; Potomac River, Bryans Point, Md., to Riverside, October 19 and 20, 1909; September 13 to November 11, 1911; June 7 to December 3, 1912. Two fish were caught with hook and line, using dough for bait, at Bryans Point, Md., October 21, 1910.